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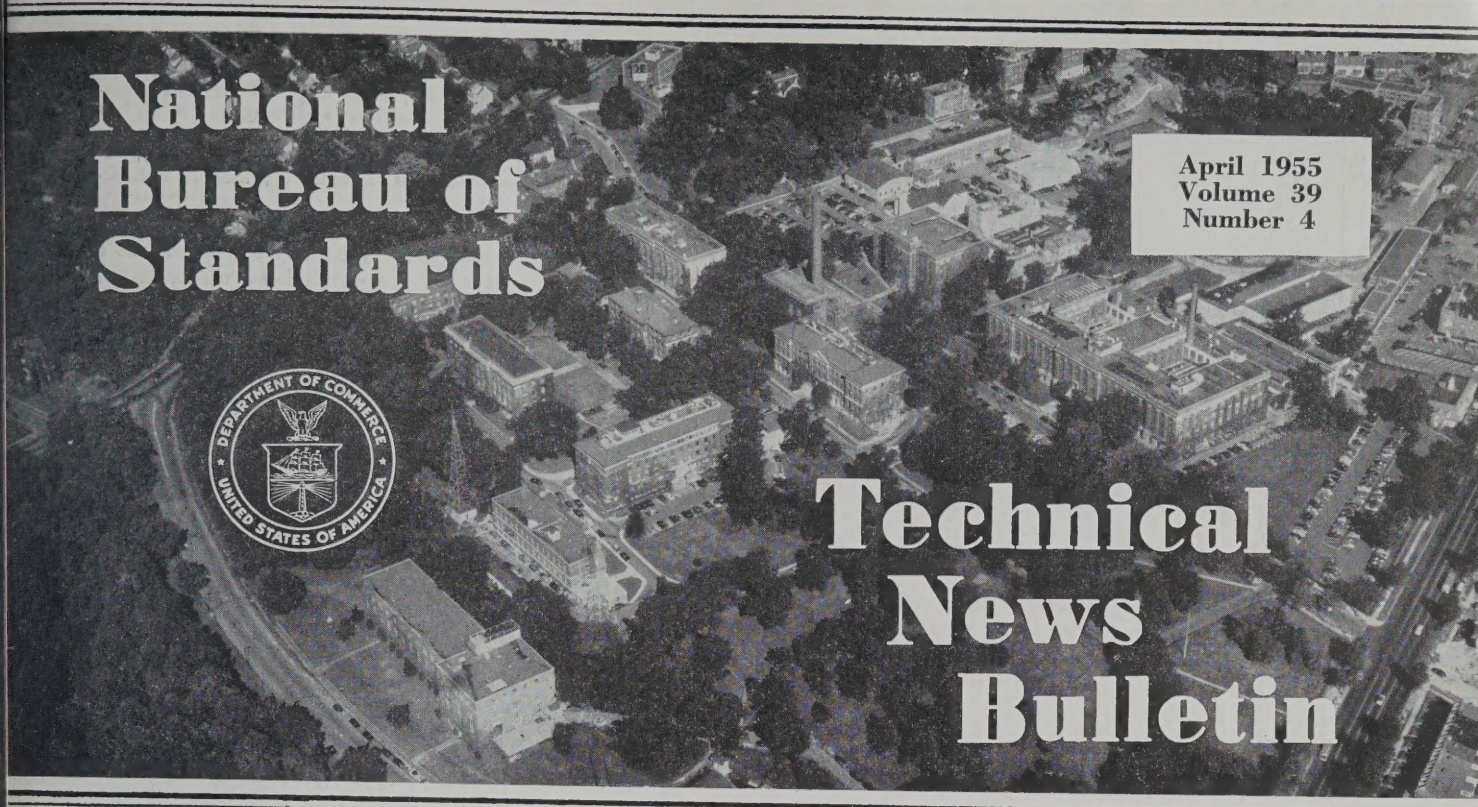

Technical News Bulletin

International Comparison of Radium Standards

RECENTLY the British primary radium standard and the Canadian national radium standard were brought to this country for comparison with the two United States primary radium standards kept at the National Bureau of Standards. The work was performed by the NBS radioactivity laboratory under the leadership of W. B. Mann. The intercomparisons were conducted over a period of 12 days and were made as exhaustive as possible, using the NBS standard electroscope, a Peltier-effect radiation balance, and Geiger and scintillation counters. The results closely confirm the ratios of the weights (as determined by Hönigschmid in 1934) of the British and the two United States standards. However, a new weight, differing from its previous value by approximately 0.5 percent, was derived for the Canadian standard.

In 1949 five radium preparations were measured for radium content at the laboratories of the Canadian National Research Council in Ottawa, the National Physical Laboratory in Teddington, England, and at the National Bureau of Standards, by comparison with the national primary standards of the three countries. After correcting for radiation absorption in the radium salt and in the container walls, discrepancies of between 1 and 2 percent were found to exist among the results obtained by the three laboratories.

Some concern was felt lest these discrepancies might have arisen from errors in the national primary standards themselves. The participants therefore agreed to compare these primary standards directly.

The first such opportunity presented itself in the summer of 1952 when the United States primary radium standard was taken first to Teddington and then to Ottawa for comparison with the United Kingdom primary standard, and the Canadian national radium standard respectively. These results have been reported by W. E. Perry [1] and W. S. Michel.[2] The present intercomparison provided an opportunity to work with all these national primary standards at one time. It also permitted the Bureau to intercompare four different methods of radium measurement.

The two United States primary radium standards (*A* and *D*, tables 1 and 2) were prepared by Hönigschmid in 1934 and were acquired by NBS in 1936. Their weights correspond to 38.23 and 20.45 mg of radium element, respectively. These two standards also underwent gamma-ray comparison with the 1911 Paris and Vienna standard at which time their masses corresponded to only 38.13 and 20.38 mg, respectively, of radium element, as of June 1934. The British standard (*B*, tables 1 and 2), another Hönigschmid preparation sealed in June 1934, has a weight which corresponds to 15.60 mg of radium element as of that date. It is solely a standard by weight and was not compared with the 1911 Paris and Vienna standards. These three standards have low ratios of material volume to container-tube volume. It is therefore to be expected that with the standards in a horizontal position and the grains of radium chloride distributed evenly

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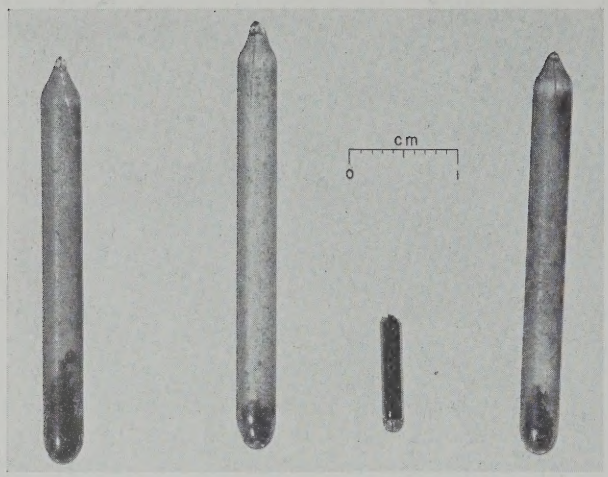


Four national radium standards which were intercompared at the Bureau. Standards are (left to right) American, British, Canadian, and American. Work was performed using NBS standard electroscope, a Geiger-Müller counter, a scintillation counter, and a Peltier-cooling radiation balance.

along the tube, the gamma-ray source self-absorption of the standards would be very nearly the same.

The Canadian national radium standard (*C*, tables 1 and 2), however, is shorter and of smaller diameter than the Hönigschmid preparations, and it is tighly packed with radium chloride. It was sealed in June 1930 by the Union Minière du Haut Katanga. Its contents were taken from two tubes of radium chloride that had been prepared by the Union Minière in June 1924. Its weight was derived by gamma-ray comparison in 1933 with the 1911 Paris and Vienna standards, and corresponds to 24.23 mg of radium elements as of June 1934.

Four separate measurement systems were used in turn to intercompare the four radium standards. First, the NBS electroscope was used without modification.

The Geiger counter used for the second method was a neon-halogen-filled tube surrounded by a sheath of lead ¾ in. thick. The third measurement system used a scintillation counter consisting of a thallium-activated sodium-iodide crystal mounted on the face of a photomultiplier tube. The tube discriminator was set to accept pulses corresponding to gamma-ray energies greater than 1 Mev. The final system employed an improved radiation balance recently developed at the Bureau.[3] This device balances the heat energy emission from a radioactive source against Peltier cooling, the energy emission from another radioactive source, or both.

The four standards were measured relative to each other by comparison of each of six possible combinations of pairs. In table 1 are shown the complete results for the six pairs of standards. The last line of the table shows the weight ratios for the same six pairs. The weight ratio of the Canadian standard *C* is, however, only a derived one. For this reason, any ratio involving this weight is shown in quotation marks. On the other hand, the ratios *A/B*, *A/D*, and *B/D* are the ratios of Hönigschmid's own weighings.

A statistical survey of the data was carried out by W. S. Connor and W. J. Youden of the NBS statistical engineering laboratory to obtain the best estimates of the masses of radium element in *A*, *B*, and *D*. Table 2 lists these estimates as of June 2, 1934.

By comparing the calorimetric ratios obtained with the radiation balance (table 1) with the weight ratios (computed from data in table 2), it was found that the derived weight of the Canadian national radium stand-

[1] A gamma-ray comparison of British and United States national radium standards, *by W. E. Perry, Proc. Phys. Soc. (in press)*.

[2] The intercomparison at the National Research Laboratories of a primary radium standard of the National Bureau of Standards and the Canadian national radium standards, *by W. S. Michel, Natl. Research Council Can., Rept. No. PR–192 (June 23, 1953)*.

[3] Use of Callendar's "radio-balance" for the measurement of the energy emission from radioactive sources, *by W. B. Mann, J. Research NBS* **52**, *177 (1954) RP2486;* Radiation balance, *NBS Tech. News Bull.* **39**, *8 (1955)*.

Bureau laboratory in which the national radium standards of Britain, Canada, and the United States were compared. Equipment used in the comparisons included the NBS standard electroscope (left rear) and the counters in the center foreground.

TABLE 1. *Adjusted results for the ratios of the four international standards*

Method	A/B	A/C	A/D	B/C	B/D	C/D
NBS standard electroscope	2.441	1.570	1.870	0.6429	0.7661	1.192
Geiger-Muller counter	2.461	1.582	1.885	.6430	.7659	1.191
Scintillation counter	2.478	1.579	1.889	.6370	.7624	1.197
Radiation Balance	2.449	1.523	1.873	.6220	.7647	1.229
Weighing	2.451	"1.578"	1.869	"0.6438"	.7628	"1.185"

TABLE 2. *Best estimates, in milligrams, of the masses of the Hönigschmid radium standards, as of June 2, 1934*

Standard	A	B	D
Hönigschmid's mass	38.23	15.60	20.45
Mass derived from NBS standard electroscope	38.227	15.611	20.446
Mass derived from Geiger-Müller counter	38.235	15.598	20.443
Mass derived from scintillation counter	38.235	15.595	20.444
Mass derived from the radiation balance	38.235	15.608	20.435

ard, *C*, is low by about 3 percent. However, this does not allow for the difference in sealing dates between *C* on the one hand and *A*, *B*, and *D* on the other. This difference involves a compensating polonium-growth correction of about 1.8 percent. When the correction is applied, comparison of *C* with the other three standards gives the result that there were 24.36 mg of radium element in the Canadian national standard as of June 1934. This value may be somewhat low as some radium D on the walls of the original two tubes (prepared in 1924) may have been lost on transfer when the Canadian standard was resealed in 1930. In this event, the polonium correction will have been too great.

The new weight derived for the Canadian standard indicates that no correction for differences in source self-absorption was made in its comparison with the 1911 Paris and Vienna standards. The difference between the new weight and that obtained by comparison with the 1911 Paris and Vienna standards (24.23 mg as of June 1934) would indicate a self-absorption correction of 0.53 percent. The absorption correction determined by W. S. Michel (see footnote 2) was 0.94 percent; the difference between these two values could be a measure of the loss of radium D and polonium–210 in the transfer of June 1930.

For further technical details, see Comparison of four national radium standards, Part 1, Experimental procedures and results, *by T. I. Davenport, W. B. Mann, C. C. McCraven, and C. C. Smith;* Part 2, Statistical procedures and survey, *by W. S. Connor and W. J. Youden, J. Research NBS* **53**, *267 (1954) RP2544.*

Accurate Audiofrequency Instruments

ACCURATE measurements of audiofrequency current and voltage can be made easily and rapidly with two instruments devised by the Bureau. The first, known as a *volt-ampere converter,* provides 0.05 percent accuracy for laboratory use in conjunction with a d-c potentiometer. The second, called a *thermocouple voltammeter,* is a portable, direct-reading device with an accuracy of 0.5 percent. Development was carried out by F. L. Hermach and E. S. Williams of the NBS electrical instruments laboratory.

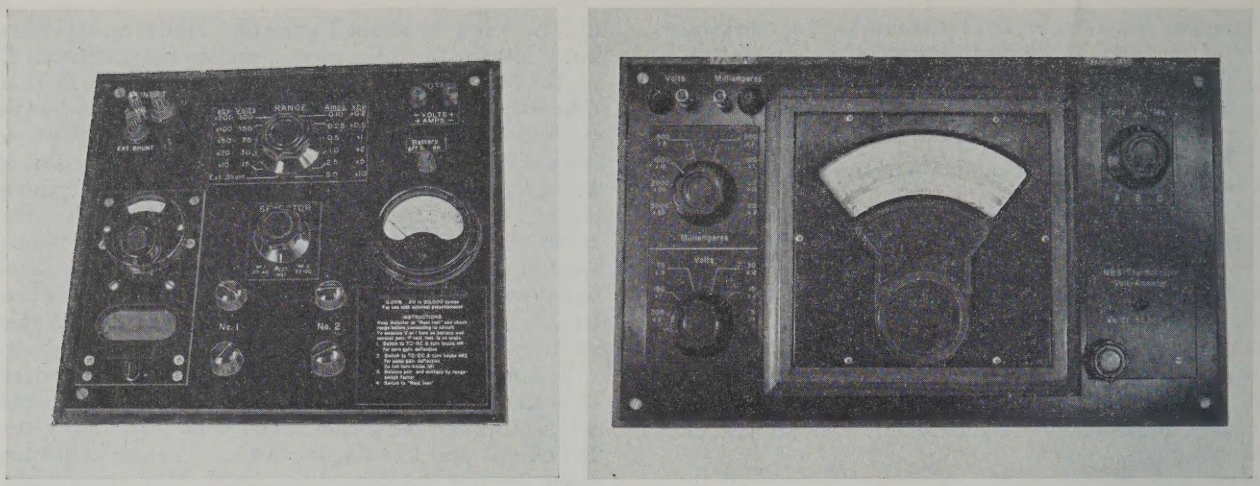
Higher audiofrequencies are being used to an increasing extent in aircraft and various electronic applications because of the saving in weight thus obtained. This has brought about a need for instruments that can accurately measure alternating currents and voltages at frequencies as high as 20 kilocycles per second—the upper limit of the audio range. Because the Bureau maintains the National primary electrical units in the form of d-c standards, it was necessary to develop highly accurate electrothermic transfer standards [1] which can be calibrated on direct current and then used in audiofrequency measurements of voltage, current, and power. This same principle of electrothermic transfer is utilized in the volt-ampere converter and the thermocouple voltammeter.

The NBS electrothermic transfer instruments make use of thermal converters. Each converter consists essentially of a conductor, heated by the alternating current to be measured, and a thermocouple, one junction of which is thermally connected to the heater at its midpoint. The value of the direct voltage produced in the thermocouple thus depends on the value of the alternating current measured.

In the volt-ampere converter, the heater of a single thermal converter is connected in series with appropriate resistors for voltage measurements and in parallel with appropriate shunts for current measurements. The resulting output electromotive force of the thermocouple is balanced against the voltage from an internal d-c "bucking circuit." Balance is indicated by the null reading of a built-in galvanometer. The heater is then switched to an internal d-c circuit, which is adjusted to give the same output emf and therefore equivalent heater current and voltage drop. The voltage across a portion of this circuit is measured with an external potentiometer and is multiplied by a simple factor to obtain the unknown alternating voltage or current. This instrument is self-contained, and requires no external d-c source or controls.

The circuit of the volt-ampere converter is designed

[1] Thermal converters as ac-dc transfer standards for current and voltage measurements at audiofrequencies, *by F. L. Hermach, J. Research NBS* **48**, *121 (1952) RP2296;* Transfer standards for audiofrequency tests, *NBS Tech. News Bull.* **36**, *42 (March 1952).*



Portable multirange thermocouple instruments developed for rapid accurate measurements of current and voltage in audiofrequency range. Volt-ampere converter (left) is designed to be used with a d-c potentiometer in 0.05-percent accuracy range. Thermocouple voltammeter (right) is a conventional multirange instrument, except that it is provided with additional circuits and components to permit using its indicating instrument to check the thermoelement. These instruments were developed for a-c measurements where rapidity and convenience of operation are of greater importance than the very high order of accuracy required in primary standardization work.

so that the measured alternating quantities are not dependent upon the conversion characteristics of the thermal converter nor on the resistance of the heater. They are dependent only on the potentiometer reading and the internal resistors, which can be made highly stable and whose values can be determined with great accuracy. The modification for voltage measurements consists in adding to the internal d-c circuit a resistor equal to the resistor connected in series with the thermal converter in the a-c position of the selector. For current measurements, a resistor equal to the shunt resistance is added to the d-c circuit. These compensating circuits have been found to be practical, and the added resistors need be of only moderate accuracy.

A 7.5-ma, 10-mv thermal converter of the insulating-bead type (in which one thermocouple junction is attached to the heater by an electrically insulating bead) is used in the volt-ampere converter. This thermocouple has an a-c–d-c difference of not more than 0.01 percent at audiofrequencies. The a-c resistors for the voltage ranges and the two lowest current ranges are high-grade 0.05-percent audiofrequency resistance cards. The four-terminal bifilar (parallel-strip) a-c shunts for the 5- and 2.5-amp ranges were constructed at NBS of 8-mil manganin strip 0.5 cm wide, with 4-mil woven-glass tape as insulation. Bifilar shunts of No. 20 manganin wire were constructed for the 1- and 0.5-amp ranges. Considerable care was taken in connecting all of the a-c shunts to minimize inductive coupling between the current and potential circuits of the shunts. These arrangements were adequate to keep the a-c impedance within 0.05 percent of the d-c resistance, even at 20 kc. The wire and strip were initially annealed at 500° C, and the completed shunts were aged at 150° C for 24 hours before final adjustment.

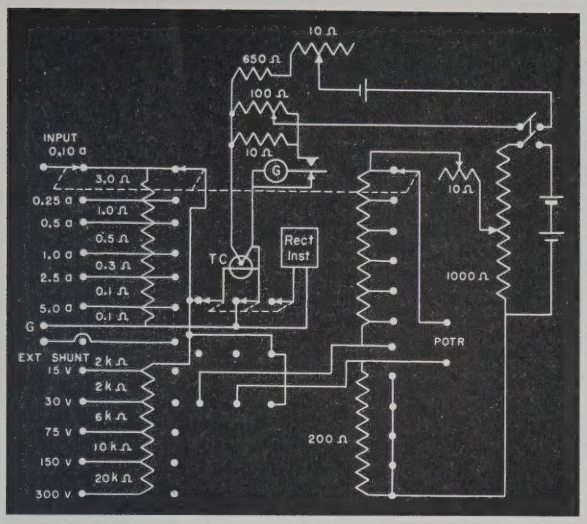
Newly developed commercially available rotary switches with enclosed solid-silver contacts and a unique internal circuit are important components in the instrument. Mercury cells of 3-amp-hr capacity are used as the internal d-c sources because of their flat discharge-voltage characteristic and very long shelf life. The combined drifts in the balancing circuit and the thermal converter are less than 0.001 percent per minute.

A useful feature of the volt-ampere converter is a 7.5-ma, 0.5-volt rectifier instrument, which is switched in place of the heater when the thermal converter is connected to the internal d-c source. This instrument tells at a glance what effect circuit changes have on the measured current or voltage. It also indicates within 5 percent what voltage to set on the potentiometer. In addition, it can serve as a valuable overload indicator.

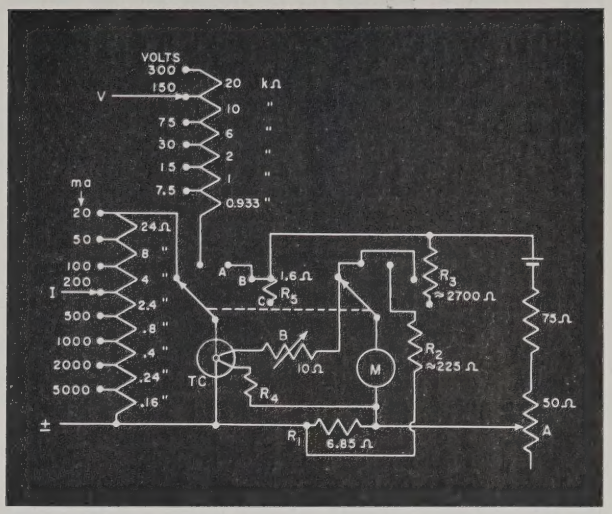
Thermocouple Voltammeter

The thermocouple voltammeter consists essentially of a d-c millivoltmeter connected to the output of the thermal converter. The sustained accuracy in service of the usual instrument of this type is limited by the relatively high temperature coefficient of the combination (0.1 to 0.3% deg C), and by changes in the converter, probably due to stress relaxation in the heater, to moderate overloads, or to leakage of air into the evacuated bulb. It is often desirable, although seldom convenient, to test such an instrument by comparison with a d-c instrument at one scale point before important measurements are made with it. However, in the NBS instrument the d-c millivoltmeter itself, together with appropriate resistors, is arranged as a milliammeter to provide for the important single-point check of the thermal converter, and adjustable resistors are incorporated to compensate for any changes. Wiring is designed so that voltage and current can be measured successively in the same circuit without changing leads. The over-all temperature coefficient of the instrument is less than 0.02 percent per deg C.

The thermal converter is of the same type as that used in the first instrument. This is also true of the



Wiring diagram of the NBS volt-ampere converter.



Wiring diagram of the NBS voltammeter.

a-c resistance cards for the voltage ranges. Likewise, a bifilar manganin resistor is connected in series with the heater of the converter to adjust it to the proper value. A ring shunt was constructed for the current ranges, with commercial a-c resistance cards for the four lower ranges and bifilar manganin wire and strip for the higher ranges.

No overload protection has been built into this instrument, but matching thermal converters are used for replacement. It has been found possible to select converters in this current range from larger lots, which match within 0.3 percent of full scale when adjusted for equality of millivoltmeter deflection at rated current. Thus the expense of recalibration should not be necessary in case of burnout.

A-c–d-c difference and temperature coefficient tests indicate this voltammeter has an accuracy within 0.5 percent over an extended temperature range. Construction of an instrument of this type accurate to 0.25 percent might prove feasible but would depend largely on inherent stability and readability of the millivoltmeter.

Both thermocouple instruments have proved very useful at the National Bureau of Standards. The volt-ampere converter serves as a standard for the calibration of a-c ammeters and voltmeters in the 0.75 percent-accuracy class or better that are sent to NBS for certification. The second instrument is used for general measurements at audiofrequencies and for tests of electronic and panel instruments.

Development of these instruments has demonstrated the high order of accuracy attainable over wide frequency ranges by application of the transfer principle to the measurement of both current and voltage. It is hoped that a wider laboratory use of electrothermic instruments may result from the reductions in the usual limitations of conventional thermocouple instruments that have been accomplished by these new circuits.

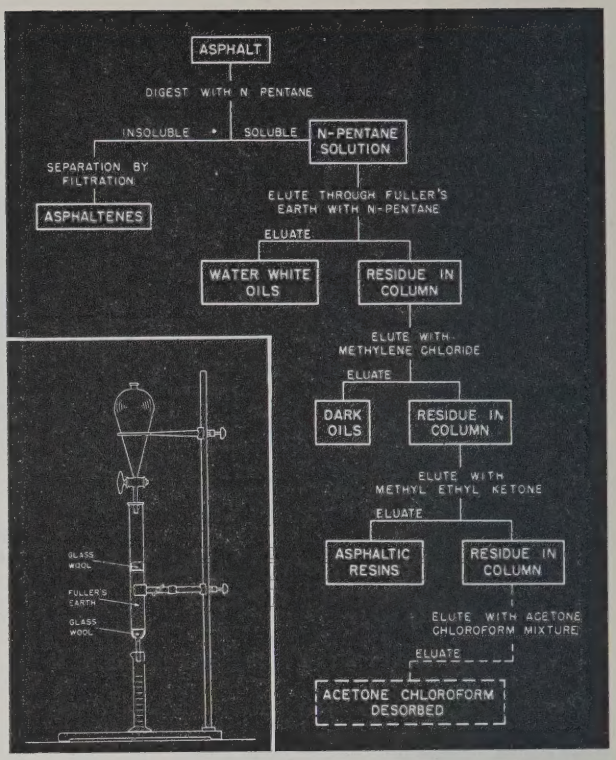
For further technical details, see Multirange audiofrequency thermocouple instruments of high accuracy *by F. L. Hermach and E. S. Williams, J. Research NBS* **52**, *227 (1954) RP2494.*

Chromatographic Fractionation of Roofing Asphalt

TO FACILITATE THE STUDY of the degradation effects of weather exposure on asphalt, L. R. Kleinschmidt of the NBS building technology laboratories has developed a simple, inexpensive method for separating asphalt into four groups of components having distinctly different physical characteristics. Analysis of the individual components is expected to yield further information on the part that each component plays in the weathering process.

In this method the asphalt is dissolved in *n*-pentane, and the resulting soluble and insoluble materials are separated. After the insoluble materials—asphaltenes—are removed, the resulting solution is absorbed on fuller's earth in a chromatographic fractionating column. The saturated fuller's earth is then washed with solvents to separate the individual components.

The NBS study of the degradation of roofing asphalts is sponsored in part by the Asphalt Roofing Industry Bureau. The objective of the investigation is to determine why some asphalts resist weathering better than others, how to distinguish between those that are highly resistant and those that weather poorly, and how to improve the weather resistance of the poor ones. The results promise to be of significant interest to the asphalt industry, which produces over 14 million tons of asphalt annually. Approximately one-fourth of this



Flow diagram of method for separating asphalt into its major components. Analysis of components is expected to yield further information on part that each plays in the asphalt degradation process when material is exposed to the weather. *Inset:* Fractionation assembly for chromatographic separation of roofing asphalt. After asphaltenes are removed, resulting solute is adsorbed on the fuller's earth in the column. A series of solvents is poured into the column and the individual major components are washed out, one by one.

amount is used for roofing products while the remainder is used mainly in highway construction.

The first step in the NBS separation process is the isolation of the asphaltene group. The asphalt is digested in *n*-pentane until it is thoroughly disintegrated and then filtered through a gooch crucible. The resulting filtrate is concentrated and poured into the fractionating column assembly. The column is first washed with *n*-pentane, then with methylene chloride, and then with methyl ethyl ketone. On evaporation of the solvents the *n*-pentane solution leaves a water-white, mobile oil; the methylene chloride solution leaves a dark orange semisolid; and the methyl ethyl ketone solution leaves a glossy black semisolid. Strongly adsorbed material which is not removed by the three solvents is recovered by passing acetone containing 10 percent water through the column, followed by chloroform.

After the components are separated, they are then available for chemical analysis or for weathering studies. Additional chemical analysis can now be more easily performed to subdivide each component into its basic constituents. Specimens weathered under either natural or simulated conditions will give further information on the relative importance of each component in the degradation process.

The method is designed primarily for processing not more than 5 grams of asphalt, the approximate amount used for weather exposure specimens. However, it is readily adaptable to larger quantities simply by increasing the size of the fractionating column. The procedure is rapid, does not require costly equipment, and can be performed by easily trained personnel.

For further technical details, see Chromatographic method for the fractionation of asphalt into distinctive groups of components, *by L. R. Kleinschmidt, J. Research NBS* **54**, *163 (1955) RP2577.*

TABLE 1. *Analysis of blown petroleum asphalts softening point range 220° to 230° F*

Component	Asphalt	
	1	2
	%	%
Asphaltenes	45. 5	46. 5
Water white oils	21. 1	12. 4
Dark oils	21. 9	23. 5
Asphaltic resins	9. 6	13. 6
Chloroform desorbed	0. 5	1. 0

Linear Programming Symposium

OVER 350 mathematicians, economists, and scientists attended a Symposium on Linear Programming held in Washington, D. C. on January 27, 28, and 29, under the auspices of the Bureau and the Directorate of Management Analysis of the U. S. Air Force. The sessions, which were sponsored by the Office of Scientific Research of the Air Research and Development Command, were held in the Pentagon on January 27 and at NBS on the remaining days.

"Linear programming" problems arise in connection with planning by top management of procurement, budgeting, and similar problems, as well as in applications to scientific and economic problems of diverse interest. Mathematically, the problem to be solved is the maximization of a linear function subject to a system of linear inequalities. The Symposium included 26 lectures dealing with all phases of current research in this field. In addition, one-hour expository addresses were given by Walter Jacobs, U. S. A. F., on military applications, Alan J. Hoffman, NBS, on computation procedures, Paul Samuelson, Massachusetts Institute of Technology, on economic theory, Albert W. Tucker, Princeton University, on linear inequalities, and George B. Dantzig, RAND Corporation,

on future prospects. Stefan Vajda, Admiralty Research Laboratory, England, delivered a special address on linear programming activities in Great Britain.

The papers presented indicate that rapid progress has been made in the theory and applications of linear programming since a similar symposium was conducted in Washington under the same auspices in June 1951. A number of the papers reported practical applications. Among these was a discussion of the award of contracts by the Quartermaster Corps with strict adherence to the principle of "least cost to Government." SEAC, the NBS automatic electronic computer, has been used for over a year on this bid evaluation problem. A commercial use of linear programming was explained concerning shipping and scheduling in a multiplant operation. The solution required the determination of an optimum allocation of demand to the various plants.

Another report was on the application of linear programming to optical filter design. Here the unknowns to be determined could be either the concentrations of the various filter constituents that are to be mixed to form a single filter, or the thicknesses of the various filters that are to be placed in series. Methods of solving structure design problems by linear programming were also described. Such problems arise when an attempt is made to design framed structures for minimum material consumption using the principles of limit analysis.

A paper was delivered giving approaches to analogues of linear programming and game problems where the information about constants involves uncertainty. The results were applied to the problem of evacuating a large city in a civil defense emergency. Problems in agricultural economics were also discussed, using a stochastic (randomized) linear programming procedure to maximize the relationship between production on one hand and labor, capital, and land on the other.

Several of the talks dealt with the use of the new mathematical techniques associated with linear programming in settling or simplifying fundamental questions of economic theory concerning equilibrium conditions for a competitive economy.

Building Code Requirements for Masonry

A REVISED STANDARD of building code requirements for masonry construction has been prepared under the sponsorship of the Bureau by the American Standards Association Sectional Committee A41 on Masonry (see note at end of this article). Recently approved by the ASA as American Standard Building Code Requirements for Masonry, A41.1–1953, the Bureau published the revision in the Miscellaneous Publication Series.[1] The Bureau's participation in this cooperative effort was carried out as part of a long-term program undertaken to assist in the establishment of standard practices and in the development of improved codes and specifications in the building field.

The previous 1944 Standard was widely accepted by cities and States for use in their building codes. It was also popular among industrial groups, colleges, trade schools, and builders for its informational value in recommending methods applying to safety, standardization, and maintenance of the quality of materials and construction.

The revised publication first outlines abbreviations, definitions, and testing requirements, then discusses standards for materials and structures. An appendix amplifies the requirements set forth in the first part of the document. The principal construction materials considered are brick, stone, structural clay tile, concrete block, glass block, architectural terra cotta, plain concrete, and mortar. Reinforced masonry and thin veneers are not included. Primary structural requirements discussed are allowable stresses, lateral support, thickness, and bond. A number of miscellaneous sections include requirements for lintels and arches, chases and recesses for stairways, beam and joist supports, and protection against freezing.

Of particular interest in the new edition of the Standard is the enlarged appendix. It not only explains the background of requirements in the first part of the document, but also includes specific material of assistance to the architect and builder. These include methods for preventing entrance of water into basements, bonding with hollow units, bonding or anchorage of nonbearing walls, and many other helpful techniques that have proved successful over a period of years. The committee that prepared the document gave close attention to the basis for the various requirements listed and, wherever possible, gave "on-the-job" recommendations as well as practices to be avoided. The recommendations in general are based on long-term investigations conducted at NBS and at other laboratories in the United States and abroad.

Note: The following organizations are represented on the Sectional Committee: American Ceramic Society, American Institute of Architects, American Public Works Association, American Society of Civil Engineers, American Society for Testing Materials, Associated General Contractors of America, Inc., Bricklayers, Masons and Plasterers International Union of America, Building Officials Conference of America, Building Trades Employers Association of the City of New York, The Finishing Lime Association of Ohio, Fire Protection Group, General Services Administration—Public Buildings Service, Housing and Home Finance Agency, National Association of Real Estate Boards, National Bureau of Standards, National Concrete Masonry Association, National Crushed Stone Association, National Lime Association, National Sand and Gravel Association, National Slag Association, New England Building Officials Conference, Pacific Coast Building Officials Conference, Portland Cement Association, and Structural Clay Products Association.

[1] Building Code Requirements for Masonry, *National Bureau of Standards Miscellaneous Publication 211, available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for 20 cents.*

Dr. A. V. Astin, Director of the Bureau, is e
exhibits at Open House.

NBS OPEN HOUSE

Recent Scientific Developments Exl

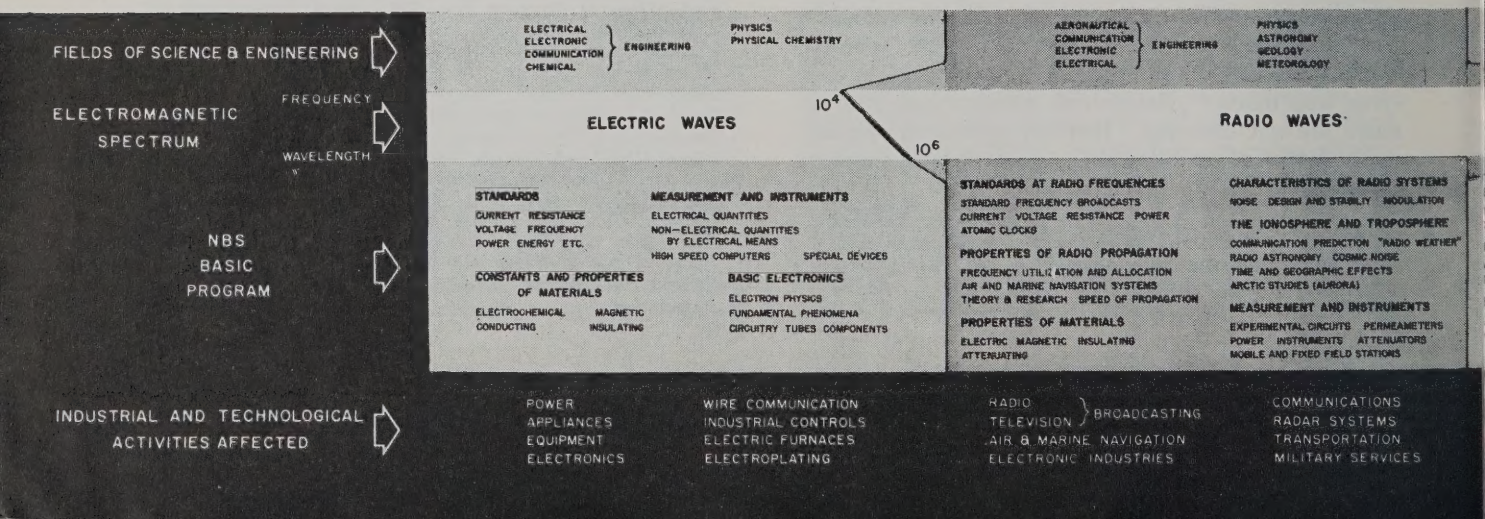
ANNOUNCEMENT of a system for "X-ray televising" the internal parts of an operating engine, the demonstration of a radiation monitor for atomic blasts, and recent developments in the science of measurement were among the highlights of an Open House held at the National Bureau of Standards during the week of February 7. The program—attended by several hundred leaders in the fields of science, industry, government, and education—stressed the significance of physical measurement standards to scientific and industrial progress and featured the first showing of two new radiation facilities: the NBS Betatron and Gamma Ray Laboratories. The Open House guests were also taken on guided tours involving the work of 14 other NBS laboratories. Participating in the program were Secretary of Commerce Sinclair Weeks, Under Secretary of Commerce Walter Williams, and members of the Bureau's technical staff.

New Facilities

The new Gamma Ray Laboratory will permit the Bureau to meet increasing scientific and technical demands growing out of advances in the use of atomic energy. Before radioactive materials and instruments for their detection can be used safely and effectively, they must be calibrated against the radioactive standards maintained by the Bureau. In recent years, the radioactive isotope, cobalt-60, has been increasingly used in place of radium for industrial X-ray photography, medical treatment, and instrument calibration. The Gamma Ray Laboratory was built to accommodate the growing demand for cobalt-60 calibration. The Laboratory also maintains radium standards for calibration of all medical radium preparations.

The Betatron Laboratory houses the Bureau's 50-million-volt betatron and 180-million-volt synchrotron. The Bureau is using the X-rays produced by these high-energy electron accelerators to develop the standards

Chart of the electromagnetic spectrum showing fields of science program of the Bureau in each area, and industrial and tech Open House, Dr. Astin used this chart to show how scientific Because of broad scope of the Bureau's work, discussion was li with electromagnetic radiation. As indicated by the chart, NB properties of materials, and instrumentation for precise measu



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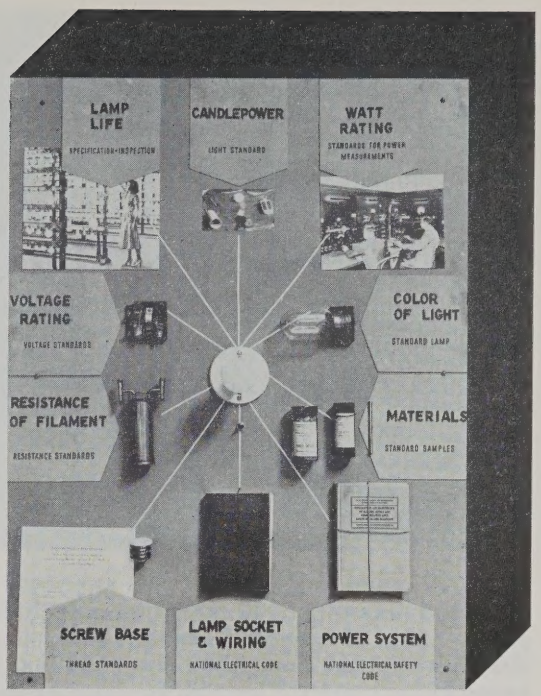


Exhibit showing 10 different ways in which activities of the Bureau enter into manufacture and use of common electric light bulbs. As indicated on exhibit, candlepower, or brightness of lamp, is determined on the basis of the national standard of brightness maintained by NBS. Likewise, the Bureau maintains standards of color which determine whiteness or "daylight" quality of the lamp. NBS electrical standards include those which provide a basis for watt and voltage rating and for determining the resistance of lamp filament. Screw thread standards insure that lamps made by different manufacturers will fit the same socket, and NBS standard samples of highly purified materials such as tungsten enable the manufacturer to maintain uniform quality by controlling composition of the materials used in making the lamp. The Bureau has also developed standard electrical safety codes for power systems. And finally, it has cooperated with other agencies in developing standard codes for lamp sockets and wiring and in developing specifications for lamp quality.

bited

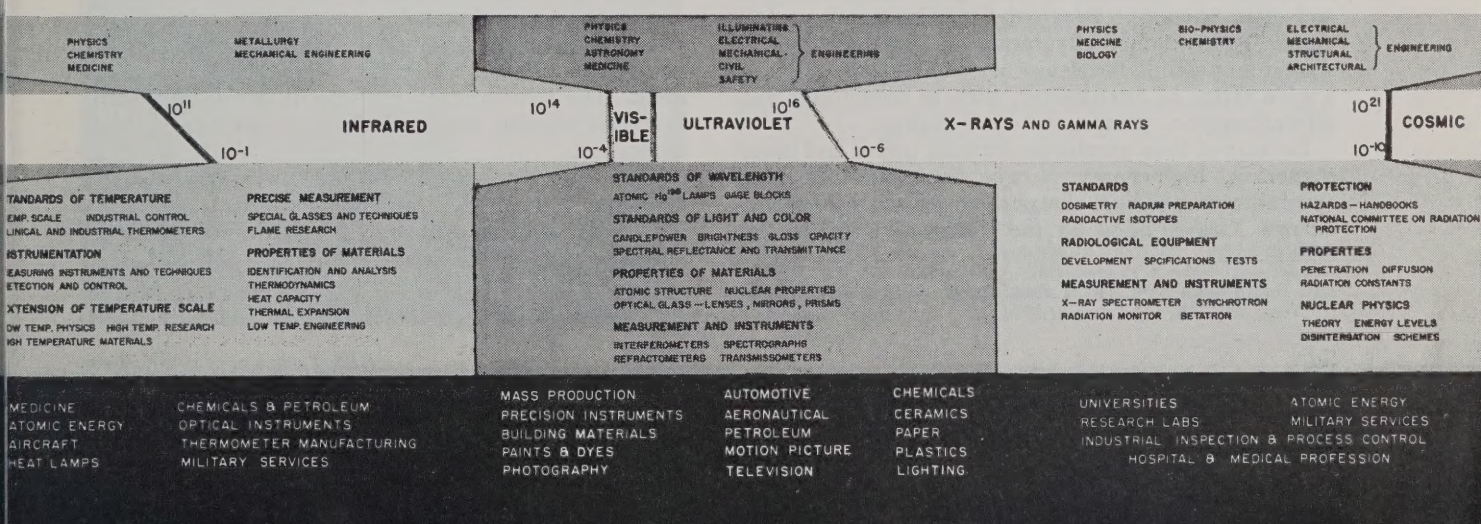
and measurement methods needed for safe application of high-energy X-rays in medicine, industry, and nuclear physics. Exact wall thicknesses and optimum types of construction for protection from these deeply penetrating radiations can be determined through laboratory research.

Standards for Science and Industry

Before touring the Bureau, the guests assembled in the Bureau's High-Voltage Laboratory to witness a lecture-demonstration by Dr. Allen V. Astin, Director of the Bureau. In his talk, entitled "Physical Standards—The Cornerstone of Scientific and Industrial Progress," Dr. Astin used the electromagnetic spectrum to bring out the relationship between the Bureau's activities and the technological economy of the Nation. Illustrating his remarks with operating apparatus, he discussed the Bureau's work in developing the precise standards of measurement required by modern science and industry in the various ranges of the spectrum.

Starting with the national standard meter bar and kilogram—on public exhibition for the first time—Dr. Astin moved on to a discussion of the hundreds of physical measurement standards which the Bureau has derived from these basic standards since its establishment in 1901. He chose an ordinary electric lamp as an example of a modern technological product and showed how its uniform quality is related in 10 different ways to activities carried on by the Bureau. Included are NBS activities which provide standards for measurement of brightness, color, electrical resistance, watt rating, and voltage rating. Also involved are NBS standard samples of the lamp materials—brass.

d engineering concerned with each part of the spectrum, basic logical activities affected. In his lecture-demonstration at the industrial progress are related to the Bureau's basic program. ed to those fields relating to various regions of science dealing concerned in each of these areas with scientific standards, basic ment.



Experimental setup used for X-ray televising the internal parts of an operating mechanism at the Open House. A small single-cylinder compressor is shown on the black cloth in position for X-ray examination. High-energy X-rays from the Bureau's betatron (background) fall on the compressor after passing through a slot in the heavy radiation shield made of concrete slabs and lead bricks. The sodium iodide crystal mounted just in front of the compressor converts the resulting X-ray image into a visual image, which is reflected by a mirror to the television camera placed outside the direct X-ray beam.

glass, and tungsten; screw thread standards to insure proper fitting of lamp and socket; specifications for lamp quality; and standard electrical safety codes for power systems and for lamp sockets and wiring.

X-Ray Development

Dr. Astin illustrated NBS work in the X-ray range of the spectrum with demonstrations of the radiation monitor and the system for X-ray televising the interior of an engine. The radiation monitor [1] is a remote-control system which automatically measures radiation intensities in the vicinity of an atomic explosion and transmits the data by radio to a centrally located headquarters. The system was developed at the request of the Division of Biology and Medicine of the Atomic Energy Commission for use in nuclear tests. Its overall design was worked out by L. Costrell and associates of the Bureau's nucleonic instrumentation laboratory. As Dr. Astin explained the operation of the monitor, it received and recorded the background radioactivity level at a remote station near Reno, Nevada.

The X-ray televising demonstration used highly penetrating radiation from the betatron in combination with a technique recently developed at the Bureau for converting high-energy X-rays into visual images. The audience saw clearly the moving piston, piston rod, and other parts in a televised X-ray image of a small one-cylinder engine. By means of this technique it should be possible to televise the internal operation of a wide range of mechanisms, such as automotive and aircraft engines, pumps, and other devices.

Because of their greater penetrating power and lower scattering, high-energy X-rays from betatrons and synchrotrons produce sharper images than do lower-energy X-rays, allowing the observation of greater detail and the detection of more minute flaws in metallic equipment. However, until now their use in studying the internal operation of heavy machinery has been confined largely to X-ray photographs. Suitable methods for observing the interior of a mechanism while it operates have been lacking.

The Bureau's system, developed by Dr. J. S. Pruitt of the NBS Betatron Laboratory, makes use of an instrument called a pattern amplifier,[2] which acts as an X-ray intensifier, continuously detecting, amplifying, and displaying low-intensity X-ray images. The major component of the pattern amplifier is the converter—a large, cylindrical, thallium-activated sodium iodide crystal, which converts X-ray images into optical images. When bombarded with an X-ray beam, the crystal emits visible light. If the flat faces of the crystal are perpendicular to the X-ray beam, a visible replica of the X-ray image may be observed along the beam axis. When the pattern amplifier is used in conjunction with a high-intensity, high-energy X-ray source such as the NBS 180 Mev synchrotron, it can continuously display images of parts hidden by as much as 18 inches of steel or 7½ feet of concrete. The visual image may be detected in several ways. It may be observed directly by eye, photographed with an ordinary camera, or observed with a remotely controlled television camera.

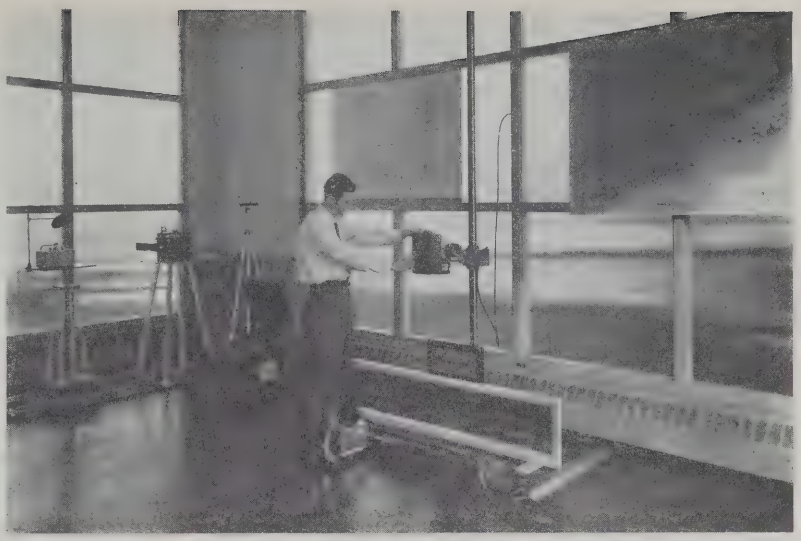
New Calibration Services

In discussing the work in the radio range, Dr. Astin announced that the Bureau is working with the Air Force and the Navy Bureau of Aeronautics in setting up a recalibration center to insure the reliability and efficiency of electronic equipment in military aircraft. About half the cost of a modern fighter airplane now goes into electronic devices for navigation, communication, fire control, and other purposes. In order for this equipment to work together as a unit, each of the separate components must be specified, constructed, and evaluated according to certain reference standards. The recalibration center will periodically calibrate the working standards used in maintaining such equipment.

One of the demonstrations in the visible range of the spectrum concerned three-color brightness standards now under development at NBS for the television in-

[1] Radiation monitor for atomic explosions, *NBS Tech. News Bull.* **38**, *116* (*August 1954*).

[2] Research in high-energy X-rays, *NBS Tech. News Bull.* **38**, *173* (*December 1954*).



A portion of the Gamma Ray Laboratory, one of two new radiation facilities on display at the Open House. The Laboratory is used for calibration of radioactive isotopes and of radiation detection instruments. A staff member is shown adjusting a radiation survey instrument before exposing it to gamma rays from a 200-curie cobalt-60 source kept in a shielded cavity in the floor below. A scale on the vertical support indicates the distance from the source to the meter. To the left of the mirror is a radiation-shielded container which the Bureau developed in cooperation with the Air Force to use in transporting small radioactive cobalt sources of 40 millicuries or less. To the left of the container is a portable cesium-137 radioactive source developed for the Navy Bureau of Ships.

dustry. Color television tubes contain red, green, and blue fluorescent materials, which in combination produce all the required colors in the image. The Bureau's standards are for use in measuring the brightness of the three components. The visitors saw the television standards in the form of squares of transparent colored glass, lighted from behind. The colors match closely those used in color television tubes.

Another demonstration in the visible range illustrated the method used at the Bureau to calibrate inch gage blocks to the nearest millionth of an inch. This is done by observing the displacement of the interference fringes formed when light is reflected between the upper ends of the blocks and a transparent surface that is flat within one millionth of an inch. Dr. Astin mentioned that the roller bearing industry has recently asked the Bureau to develop methods for calibrating master gage blocks to the nearest 10-millionth of an inch so that antifriction bearings may be mass-produced to tolerances of 1 part in a million. Attainment of the required precision in calibration will require considerable research, but the Bureau hopes to accomplish this by using a mercury 198 lamp as a light source. The mercury 198 lamp emits a pure green light whose wavelength, near 21 millionths of an inch, can be reproduced with an accuracy better than 1 part in a billion. The Bureau has already used this wavelength to make length measurements with an accuracy of 1 part in 100 million and has recommended the mercury 198 light source as an ultimate standard of length.

After the lecture-demonstration, the guests were taken to other NBS laboratories to see demonstrations of work in the fields described below.

Precision Measurement of Length. The mass-production industries, so important in maintaining a high standard of living and in building up military capacity in times of emergency, depend largely upon closely fitting and interchangeable mechanical parts. Proper fitting and functioning of these parts in turn depend upon precisely calibrated gage blocks. NBS checks master gage blocks of industry, measuring the length of each block with an error not greater than 2 millionths of an inch per inch of length. Calibration also includes inspection for flatness and parallelism of surfaces. Industry does not use these master blocks in production work but for calibrating subordinate gage blocks. These blocks are used in turn to adjust and

X-ray image of a single-cylinder compressor as seen on the television screen. The "X-ray televising" demonstration made use of a technique recently developed at the Bureau for converting high-energy X-rays into visual images. Note the piston and piston rod above and the crankcase below.

correct gages of the shop workman who may be measuring errors within a few thousandths or ten thousandths of an inch. The Bureau calibrates master gage blocks using an interferometric method in which a gage block is measured in terms of a wavelength of light.

Measurement Problems at Supersonic Speeds. When an airplane or missile goes beyond the speed of sound, it encounters conditions and forces in air flow that are vastly different from those experienced at lower speeds. Thus, the development of high-speed jet- and rocket-powered aircraft has stimulated research into the nature of supersonic flow. In all studies of air flow, the disordered chaotic motions known as turbulence play an important role. For example, the frictional drag on an aircraft goes up rapidly as the turbulence of the flow increases. Accurate methods for measuring turbulence at supersonic speeds are therefore needed. In its supersonic wind tunnel, the National Bureau of Standards is studying the performance of a sensitive turbulence measuring instrument known as the hot-wire anemometer at air speeds up to twice the speed of sound. To measure the extremely rapid fluctuations in supersonic turbulence, wires as small as 50 millionths of an inch are required.

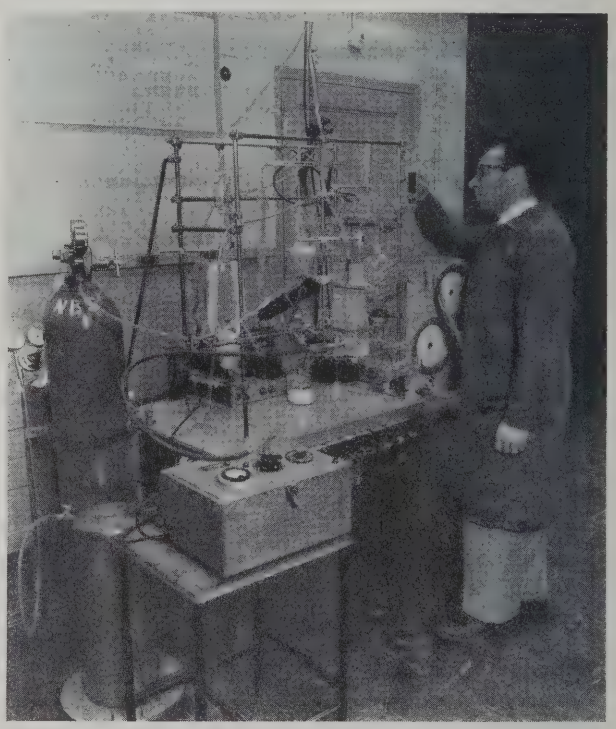
Standards and Measurements at Very High Temperatures. Melting turbine blades and "flame-out" in modern jet engines emphasize the lack of basic information on temperature measurements. One of the objectives of the NBS high-temperature laboratory is to obtain basic data required for more efficient and safe use of all high-temperature engines—rockets and gas turbines as well as jets. This objective is carried out by determining the accuracy of many methods of temperature measurement in flames and devising standards for temperature measurement in hot gases. Housewives and blacksmiths have long known that color of a flame gives an indication of temperature, and modern flame spectroscopy begins with this simple fact. However, instead of relying on visual color, scientists today use spectroscopy to analyze the wavelengths of light emitted by flames. This work represents but one phase of NBS research in temperature standards and measurements, which includes maintenance of the National Standards of Temperature.

Fatigue of Metals. Magazine accounts of recent investigations into the causes of the crashes of several jet airliners reported that the trouble was due to fatigue failure of certain parts.

Fatigue is described as the fracture that will often occur when a comparatively small fluctuating load is applied to a metal part for long periods of time. Fatigue fractures are the primary cause of service failure in certain parts of aircraft, marine, and automotive transportation equipment. Such failures often cause heavy loss of life and severe property damage. Fatigue properties of structural materials are therefore important in mechanical design.

The fatigue testing laboratory seeks a better understanding of the behavior of metals under fluctuating load which may be used in improving their fatigue strength. The laboratory is equipped with a wide variety of machines for applying fluctuating loads to metal specimens in the form of bars, plates, sheet, and wire.

Properties of Matter at Very Low Temperatures. The field of low-temperature physics is concerned with phenomena at temperatures that are almost unimaginably low, ranging from 20° K (boiling point of hydrogen on the "absolute" scale) down to absolute zero. On the ordinary Fahrenheit temperature scale this region falls below *minus* 422 degrees. At these temperatures the properties of matter undergo extraordinary changes. For example, metals such as lead and tin, ordinarily poor conductors of electricity, become super conductors with complete loss of electrical resistance. Also, near absolute zero liquid helium will flow through constrictions without resistance. The field of low-temperature physics represents an area of research in pure science in which the objective is new basic knowledge about matter and the universe. It is expected that



Atomic flame apparatus demonstrated in one of 16 open laboratories. Round flask at right is filled with a bluish green flame produced by the direct combination of oxygen atoms with acetylene gas at very low pressure—less than 1/1000 atmosphere. This pressure is equivalent to an altitude of about 200,000 feet. Oxygen atoms are produced in quantity by an electric discharge, then introduced into a partially evacuated tube containing the acetylene. By studying atomic flame, NBS hopes to learn more about burning process so that fuels may be used more efficiently in jet engines and industrial plants. Measured temperature within the flame varies from 1,200° to 20,000° F., depending on the method of measurement used. The Bureau is attempting to devise a way of obtaining the actual temperature of the flame.

A part of the metal fatigue demonstration. The Bureau is carrying on research in this field to learn why metals fail in fatigue and how fatigue failures may be prevented. Several of the devices used in studying the fatigue resistance of different types of metals are shown. Left background is a rotating-beam device for rod specimens. On the table at center are a rotating-bending and reverse-twisting machine for study of wire specimens.

the data obtained will be valuable in a variety of ways. However, to move forward in this important field new techniques of precise temperature measurement are needed. This is a primary aim of present NBS work.

High-Speed Electronic Computers and Mathematical Analysis. SEAC, the Bureau's electronic computer, was the first automatically sequenced machine put into scheduled operation in this country.

It can remember more than 1,000 numbers and has ready access to many thousands more by means of magnetic tape or wire. It can add more than 4,000 numbers per second and multiply or divide 400 per second. Its use ranges from scientific problems such as shielding against nuclear radiation, tracing of light rays through systems of lenses, and response of airplane wings to sudden wind loads, to clerical or managerial problems such as allocation of Government purchasing contracts to bidders.

More recently, the Bureau engaged in design and development of other machines and components which go far beyond the capabilities of commercially available equipment. This work is directed toward the specialized needs of both military and regular Government operations.

Color and Its Measurement. Any color can be matched by some mixture of primary red, green, and blue lights, and the proportions required by observers of normal color vision serve as an internationally recognized specification of the color These proportions can be found indirectly by means of the spectrophotometer, the basic instrument for color measurement. The automatic recording type of this instrument draws a curve for each part of the visible spectrum showing the fraction of incident light reflected (or transmitted) by the color standard. The proportions can also be found directly from a photoelectric colorimeter calibrated by suitable color standards. The Bureau has also obtained fundamental physical data needed for the setting of color tolerances, the correct perception of color signals by both the normal and the partially color-blind eye, and the requirements for faithful color reproduction. Color standards, methods of color measurement, and systems of color designation have been developed.

Electrical Standards and Measurements. Measurement is vital to the 20 billion dollar yearly sale of electric energy and equipment. Such measurement is based on the fundamental electrical standards which NBS has established and maintained and uses to calibrate master standards for universities, private laboratories, manufacturers, utilities, and regulatory agencies.

The basic standards are known to a few parts in a million; an accuracy of about 3 parts in 10,000 (0.03%) is achieved in the Bureau's standard watthour meter by which the master standards of the public utility commissions and the power companies are calibrated. In turn their measurements are made to about 0.1 percent so that the accuracy of the customer's meter will be within 1 percent or 1 part in a hundred. Many kinds of standards are needed to meet the accuracy and uniformity requirements of modern technology in the measurement of power, energy, voltage, current, resistance, and other electrical quantities.

Rapid and Precise Analysis of Metals and Alloys. Automatic spectrometers are now employed in industry for rapid control of composition in the production of metals. Before they can be used effectively, the instruments must be calibrated by means of standards of known composition. The National Bureau of Standards prepares and issues standard samples of high uniformity and with accurately determined composition for such calibrations. With a properly calibrated instrument, an analysis may now be completed within one minute after receipt of the sample. By virtue of this high speed in analysis, the metallurgical industry can prepare alloys to proper specifications with a minimum of time and labor, thus decreasing costs and effectively increasing the volume of production from existing facilities. Standard metal samples represent only a few of the more than 500 different varieties of chemicals, ores, ceramics, and metals distributed by NBS for use in controlling chemical processes and in maintaining the accuracy of apparatus and equipment.

Properties of Heat Insulating Materials. Thermal insulation properly applied to a house or other building saves fuel in winter, reduces air conditioning or cooling load in summer and promotes living comfort during all seasons.

Numerous manufacturers produce insulating materials which are used in various types of construction and a need exists for data and performance standards. The Bureau designed an apparatus known as a guarded hot box for measuring heat flow through panels simulating building walls, floors, ceilings, or roofs. This test equipment has been accepted by the American Society for Testing Materials, industry, and other Government agencies. The heating and air conditioning laboratory also uses another hot box apparatus where wall specimens can be exposed to differences of humid-

A section of the electrical standards demonstration. Equipment at right was developed for the precise calibration of master watthour meters submitted by the power companies and public utilities commissions of the Nation. The calibration is carried out by comparing the master meters with the Bureau's standard watthour meter (circular housing, right foreground), which has itself been calibrated in terms of the national electrical standards. Directly behind the standard watthour meter are electronic timing and counting equipment used in comparison. As a result of calibration of master watthour meters at NBS, power companies are able to hold customer watthour meters to an accuracy of 1 percent.

ity as well as temperature. This allows observation of the effects of movements of water vapor and humidity on heat transfer and other important performance properties.

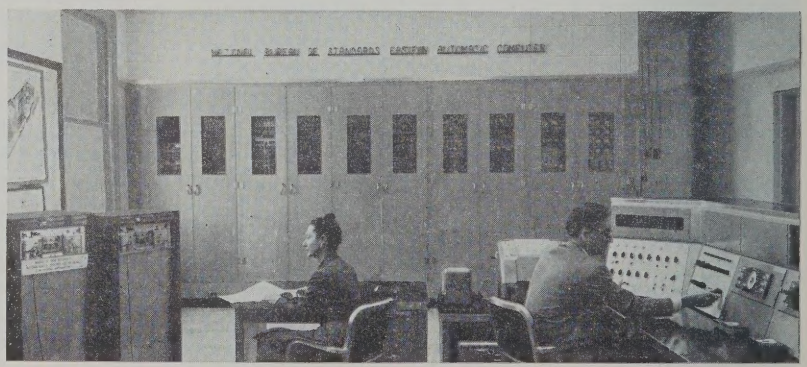
Measurement of Forces up to 10-Million Pounds. Safety in design of bridges, buildings, aircraft, ships, and automotive vehicles requires an accurate knowledge of their material and structural properties. Such knowledge is gained by Government and industry from actual tests on components or full scale structural units. The accuracy of equipment which is used in such tests depends on the precise measuring standards of force maintained and calibrated by the Bureau's engineering mechanics laboratory.

National Bureau of Standards facilities include unique equipment such as deadweight testing machines, proving rings, compression dynamometers having capacities as great as three million pounds, and the world's largest compression testing machine of ten million pounds capacity. Industry and Government rely on the Bureau's calibration service to check the accuracy of dynamometers for measuring the thrust of jet engines and rockets, and for weighing objects ranging from airplanes to the contents of bins and hoppers.

Radio Propagation Research. Increasing use of the radio spectrum by almost every phase of industry, commerce, science, and the armed forces and the accompanying technological advances in the science of communications and electronics create a growing need for more information about characteristics of radio energy under diverse conditions. To meet this need the Bureau's Central Radio Propagation Laboratory (CRPL), now occupies a new research facility at Boulder, Colorado. CRPL collects, analyzes, and disseminates data that aids global aviation, all-weather shipping and harbor control, and world-wide communications. Studies of frequency allocation and interference (such as noise from outer space) affect the establishment and operation of AM, FM, and TV broadcasting stations. The laboratory maintains the National primary frequency standard and primary standards for electrical quantities at radiofrequencies. These standards and associated research are essential to scientific and industrial applications of radio.

Atomic Structure of Crystalline Materials. X-rays are an essential tool in the study of the structure of solids because their very short wavelengths are of similar dimensions to the distances between atoms. To a very great extent all the properties of solids are dependent upon the arrangement of the atoms of which they are composed. Thus, a knowledge of this arrangement is vital to an understanding of the behavior of materials.

The precise measurement of interatomic distances



Guests at the NBS Open House were among the first to see the Bureau's electronic digital computer, SEAC, in its new location on the NBS grounds. In the background is the computer proper, consisting of arithmetic and control units and power supply. At left is a magnetic tape auxiliary memory. At right are the control console and input-output equipment.

and determination of the structure of solid materials constitute a major program of the National Bureau of Standards.

X-ray measurements are made which are extensively used in industry and research as standards for the identification and study of complex substances.

For example the data being accumulated on clays, cements, pigments, metals, glass, minerals, and plastics will be helpful in the solution of problems associated with the better utilization of these and other materials.

High Speed Impact Properties of Fibrous Materials. Fibrous materials are used in industry, public safety, and national defense in products that must repeatedly withstand very high speed impacts. For example, aircraft landing shock must be absorbed in part by textile tire cords. Similarly, automobile and truck tire cords must withstand high impact forces. In industrial sewing, thread must stitch efficiently without breaking under strains repeated 5,000 times per minute. Parachute harnesses, webbing, and shroud lines must withstand the high impact forces of opening shock after pilot ejection from high-speed airplanes, and flexible body armor must protect military personnel from exploding shell fragments. To assist industry and government in the solution of basic technical and scientific problems in development, production, and specifications for fibrous materials, the Bureau has built new precision equipment for measuring the properties of fibers, yarns, and fabrics under high-speed impact.

ASTM Issues Directory of Testing Laboratories

National Bureau of Standards Miscellaneous Publication M187, *Directory of Commercial and College Laboratories*, has been withdrawn from circulation. An up-to-date revision of this publication is now available in the *Directory of Commercial and College Testing Laboratories*, recently issued by the American Society for Testing Materials. The two organizations have agreed that ASTM undertake the responsibility for compilation and publication of the Directory in the future.

The Directory gives information regarding the location of testing laboratories together with the types of commodities and the nature of the investigations the laboratories are prepared to undertake. It is designed to be of assistance to the large number of purchasers who are not equipped to make their own acceptance tests and who therefore have hesitated to buy on specifications. It should also be of value to small manufacturers and others who are seeking testing laboratory services in the evaluation of raw materials and finished products.

The new Directory may be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania, at $1.00 a copy.

Publications of the National Bureau of Standards

Journal of Research of the National Bureau of Standards, volume **54**, number 3, March 1955 (RP2572 to RP2578 incl.). Annual subscription $4.00.

Technical News Bulletin, volume **39**, number 3, March 1955. 10 cents. Annual subsription $1.00.

CRPL–127. Basic Radio Propagation Predictions for June 1955. Three months in advance. Issued March 1955. 10 cents. Annual subscription $1.00.

Research Papers

Journal of Research, volume **54**, *number 3, March 1955. Single copies of the Journal vary in price. Single copies of Research Papers appearing in the Journal are not available for sale. The Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., will reprint 100 or more copies of a Research Paper. Request for the purchase price should be mailed promptly to that office.*

RP2572. A method for the numerical integration of differential equations of second order without explicit first derivatives. Rene de Vogelaere.

RP2573. Selected positive and negative ïons in the mass spectra of the monohalomethanes. Vernon H. Dibeler and Robert M. Reese.

RP2574. Variation in distortion with magnification. Arthur A. Magill.

RP2575. Heats of combustion and isomerization of six pentadienes and spiropentane. Frances Maron Fraser and Edward J. Prosen.

RP2576. Solid-state reactions and dielectric properties in the system magnesia-lime-tin oxide-titania. L. W. Coughanour, R. S. Roth, S. Marzullo, and F. E. Sennett.

RP2577. Chromatographic method for the fractionation of asphalt into distinctive groups of components. Lawrence R. Kleinschmidt.

RP2578. Nature of stark rubber. Donald E. Roberts and Leo Mandelkern.

Applied Mathematics Series

AMS42. Experiments in computation of conformal maps. 40 cents.

Circular

C539. Vol. IV. Standard X-ray diffraction powder patterns. H. E. Swanson, Ruth Fuyat, and G. M. Ugrinic. 45 cents.

Publications in Other Journals

Capacity of plumbing stacks. Robert S. Wyly and Herbert N. Eaton. The Plumber and J. of Heating (32 Finsbury Sq., London, E. C. 2.) **76**, No. 912, 26 (Jan. 1955).

The preparation of some aryl silanes. M. Maienthal, M. Hellmann, C. P. Haber, L. A. Hymo, S. Carpenter, and A. J. Carr. J. Am. Chem. Soc. (1155 16th St. NW., Washington 6, D. C.) **76**, 6392 (1954).

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TECHNICAL NEWS BULLETIN

U. S. DEPARTMENT OF COMMERCE
SINCLAIR WEEKS, *Secretary*
NATIONAL BUREAU OF STANDARDS
A. V. ASTIN, *Director*

April 1955 **Issued Monthly** **Vol. 39, No. 4**

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NBS Publications (*continued*)

Pyrolysis of α- and β-deuterostyrene polymers. L. A. Wall, D. W. Brown, and V. E. Hart. J. Polymer Sci. (250 5th Ave., New York 1, N. Y.) **15**, No. 79, 157 (1955).

Geographic and temporal distribution of Polar blackouts. Vaughn Agy. J. Geophys. Res. (The Johns Hopkins Press, Baltimore 18, Md.) **59**, No. 4, 499 (1954).

Plate separation requirements for standard free-air ionization chambers. Frank H. Attix and LeRoy DeLaVergne. Radiology (713 E. Genesee St., Syracuse 2, N. Y.) **63**, No. 6, 853 (Dec. 1954).

Viscometric and turbidimetric measurements on dilute aqueous solutions of a nonionic detergent. L. M. Kushner and W. D. Hubbard. J. Phys. Chem. (1155 16th St. NW., Washington 6, D. C.) **58**, 1163 (1954).

The International geophysical year, a progress report. Joseph Kaplan and Alan H. Shapley. News Report (National Academy of Sciences, Constitution Ave. NW., Washington 25, D. C.) **4**, No. 6, 1 (Nov.–Dec. 1954).

Thick target bremsstrahlung spectra for 1.00-, 1.25-, and 1.40-Mev electrons. William Miller, J. W. Motz, and Carmen Cialella. Phys. Rev. (57 E. 55th St., New York 22, N. Y.) **96**, No. 5, 1344 (Dec. 1954).

Color and turbidity of sugar products. R. W. Liggett and Victor R. Deitz. Advances in Carbohydrate Chem. (Academic Press Inc., 125 E. 23rd St., New York 10, N. Y.) **9**, 247 (1954).

Weights and measures approval seals. M. W. Jensen. Scale J. (1241 Broadway, Hamilton, Ill.) **41**, No. 5, 2 (Feb. 1955).

Publications for which a price is indicated are available only from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (foreign postage, one-third additional). Reprints from outside journals are not available from the National Bureau of Standards but can often be obtained from the publishers.

Patents

(The following U. S. Patents have beem granted to NBS inventors.)

No. 2,698,883. January 4, 1955. High-duty-cycle pulse transformer circuits. William L. Martin. Assigned to the United States of America as represented by the Secretary of Commerce.

No. 2,699,503. January 11, 1955. Atomic clock. Harold Lyons and Benjamin F. Husten. Assigned to the United States of America as represented by the Secretary of Commerce.

No. 2,699,522. January 11, 1955. Titanium dioxide rectifier. Robert G. Breckenridge. Licensed to the United States of America as represented by the Secretary of Commerce.

No. 2,700,743. January 25, 1955. Intensification of an electron beam from cold-cathode discharge. John H. Park. Assigned to the United States of America as represented by the Secretary of Commerce.

No. 2,700,185. January 25, 1955. Thermoplastic casting compositions. Max M. Lee. Assigned to the United States of America as represented by the Secretary of the Army.

No. 2,700,891. February 1, 1955. Direct reading viscometer. Montgomery R. Shafer. Assigned to the United States of America as represented by the Secretary of the Navy.

No. 2,701,526. February 8, 1955. Automatic air flow regulator. Israel Rotkin. Assigned to the United States of America as represented by the Secretary of the Army.

No. 2,702,353. February 15, 1955. Miniature printed circuit electrostatic generator. Jacob L. Herson, Saul R. Gilford, and Sachio Saito. Assigned to the United States of America as represented by the Secretary of the Navy.

No. 2,702,472. February 22, 1955. Traveling-wave transducer. Jacob Rabinow. Assigned to the United States of America as represented by the Secretary of Commerce.

No. 2,703,013. March 1, 1955. Pneumatic control and metering system. William A. Wildhack. Licensed to the United States of America as represented by the Secretary of the Navy.

U. S. GOVERNMENT PRINTING OFFICE: 1955